Electric Ships Office
PMS 320
Directing the Future of Ships Power

Surface Navy Electrical Leap Forward

Surface Navy Association

12 January 2017

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Director & Program Manager

NEXT SURFACE COMBATANT EVOLVED CAPABILITY

"In FY2030, the DON plans to start building an affordable follow-on, multi-mission, mid-sized future surface combatant to replace the Flight IIA DDG 51s that will begin reaching their ESLs [Estimated Service Life] in FY2040."

Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for FY2015

Update:

"…next Large Surface Combatant will begin in FY2030."

Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for FY2017

Big Differences:

- High Energy Weapons and Sensors
- Flexibility for affordable capability updates

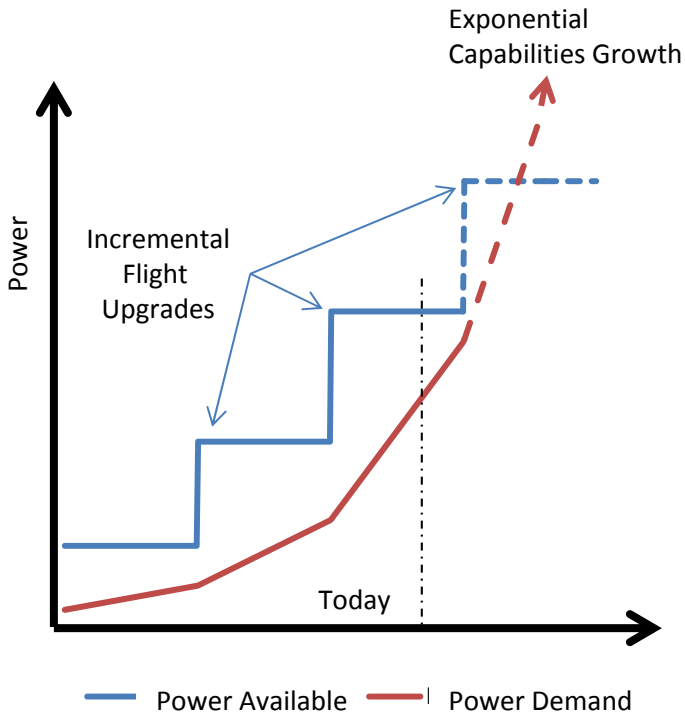
Photo by CAPT Robert Lang, USN (Ret), from site
http://www.public.navy.mil/surfor/swmag/Pages/2014-SNA-Photo-Contest-Winners.aspx

Future Power Demand Increases in the Fleet

Increases in Power Requirement Aboard Ships

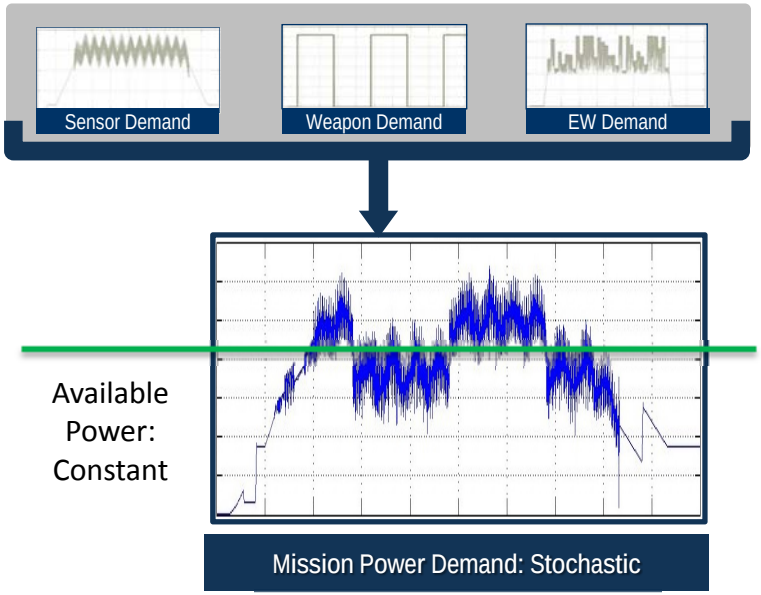
More Power

Step Change Incremental Development of Power Generation vs. Increase In Power Requirement Over Time



Different Demand

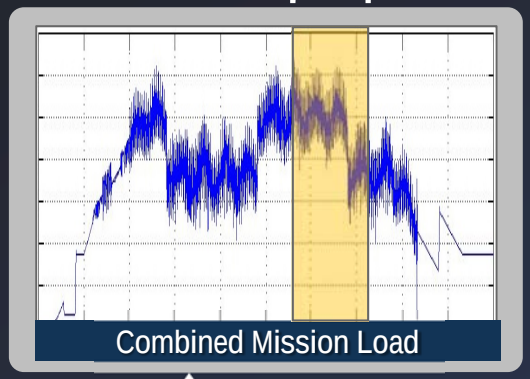
New Capabilities Demand Pulse and Stochastic Power

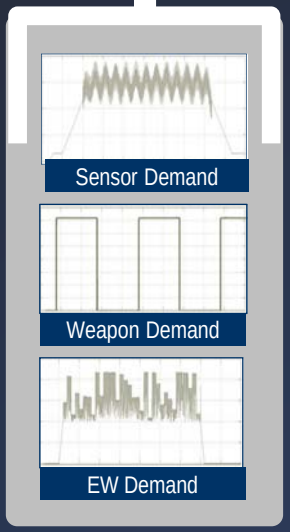


Current Available Power Aboard Ships Cannot Support Dynamic Loads

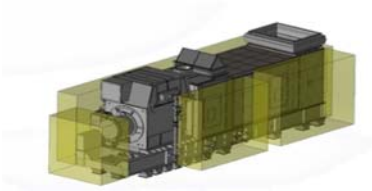
Increased Warfighting Capability to Overmatch the Threat Demands Power

CURRENT SHIPS CANNOT SUPPORT PULSE LOADS





Generators operate at continuous loading for efficiency & reliability



Current generators cannot respond quickly and dynamically for new demands

Today's Navy requires a new interface and energy storage to support dynamic loads

CURRENT MISSION SYSTEM INTEGRATION APPROACH

Each mission load brings a unique point solution-based intermediate power system

Advanced Sensors

AMDR
Air and Missile Defense Radar

Electronic Warfare

SEWIP Block III
Surface EW Improvement Program

Directed Energy

SSL-TM
Solid State Laser Technology Maturation

Future Weapons

TBD

INTERMEDIATE POWER SYSTEMS:
30-40% OF MISSION LOAD EQUIPMENT

CURRENT INTERFACE: MIL-STD 1399

Federated Systems:

- High Maintenance
- Difficult Logistics
- Not Easily Integrated
- Not Common
- Cost More
- Waste Space & Weight

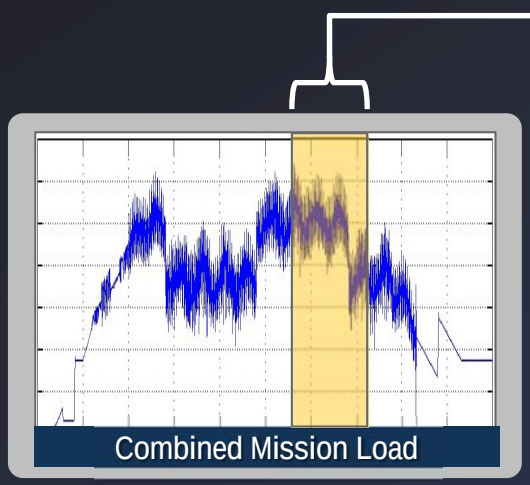
Today's Navy Pays a SWAP-C and Support Penalty

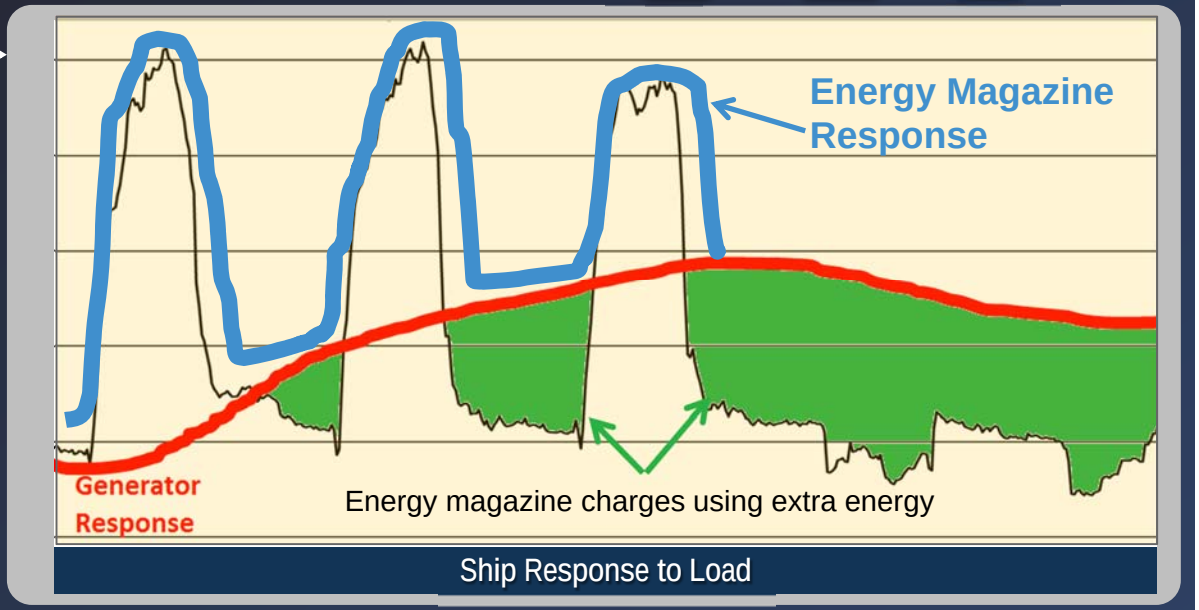
PATH TO THE FUTURE

Power is the foundation of the kill chain

- Share energy storage for new dynamic loads
- Minimize space, weight and cooling impacts
- Utilize maximum power a ship can provide

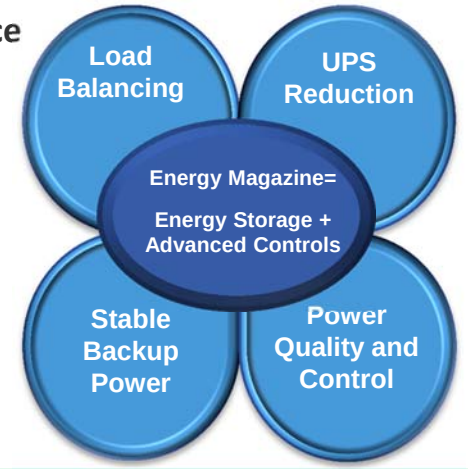
Mission Integration System: Energy Magazine





> "Energy Magazine to provide the required power from the ship's electrical system and interface with high powered weapons and sensors."
> – CNR Congressional Testimony (Mar 2014)

Energy Magazine provides an interface and energy storage when generators cannot meet demand



Flexible power and energy matches elastic mission systems

ENERGY MAGAZINE

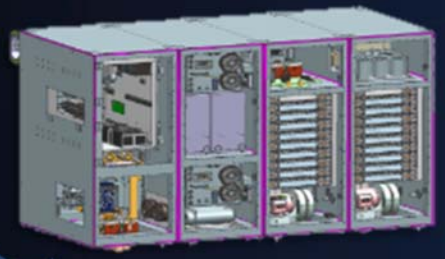
2011 — Energy Storage Module (ESM) Proof of Concept

Designed and built by RCT under ONR swampworks program

- **Strings of Lead Acid Batteries Installed in a 28' ISO container**

- Functionality: 600 kW for 10 minutes = 100 kW-hr (360 MJ)
- Status:
  - Modifying for SSL-TM Demos

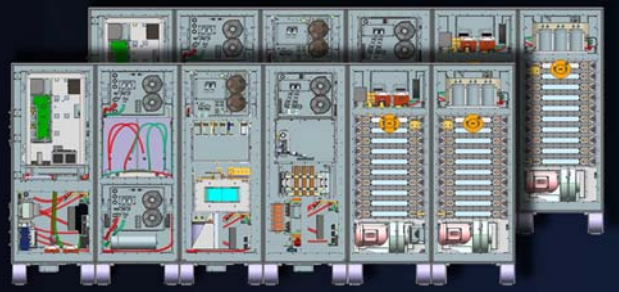
2018 — Energy Magazine Prototype (EM-L)



Single Purpose

- Functionality:
  - Support Energy for ~45 150 kW SSL shots
  - 71 kW-hr (256 MJ)
- Status:
  - Build under way at DRS
  - Integration testing / EM Demo at FSU CAPS (FY18)

2020 — Energy Magazine Mk II



Modular multi-output N+1 system will support combat system and ship survivability/reliability requirements

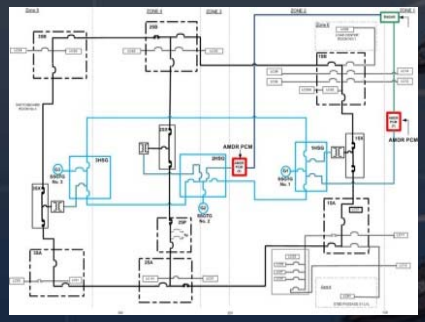
- Functionality: Peak shaving with multiple outputs for: Stable Backup Power, SEWIP, Laser, etc.
  - Support Energy for ~360 150 kW SSL shots
  - 153 kW-hr (550 MJ)
- Status
  - Evolved EM-L Design
  - Ship Production Ready in FY2020

ENERGY MAGAZINE DEMONSTRATION

EM INTERFACE IPES

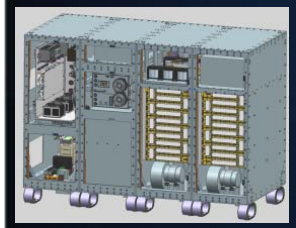
PMS 320 & ONR Modeling & Simulation

- DDG 51 Flt IIA & III Electrical System Models
  - VV&A'd
- Large Load Model
- Detailed Mission System Models



PMS 320 Energy Storage

- Energy Magazine Prototype
- UK Flywheel (Coalition Warfare Program effort)



Real Time Dynamic Simulation
FSU CAPS

Knowledge

Control Hardware in the loop (CHIL)
Power Hardware in the loop (PHIL)

PMS 320 & ONR Power & Energy Management

- Sandia NL Distributed Energy Management

Energy Magazine Demonstration Reduces Risk for integration of Pulsed High Energy Weapons

FUTURE MISSION INTEGRATION SOLUTION

Common Shared Energy Storage and Services with an Integrated Management System to Support Load Demands and Lower Ownership Costs

Advanced Sensors

AMDR
Air and Missile
Defense Radar

Electronic Warfare

SEWIP Block III
Surface EW
Improvement
Program

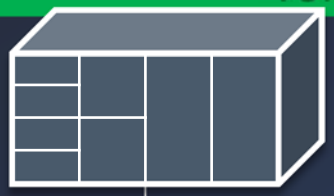
Directed Energy

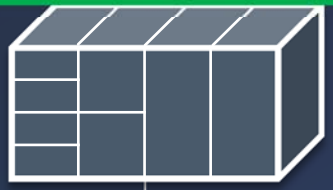
SSL-TM
Solid State Laser
Technology
Maturation

Future Weapons

TBD

FUTURE INTERFACE: MIL-STD 1399 LVDC/MVDC *(draft)*





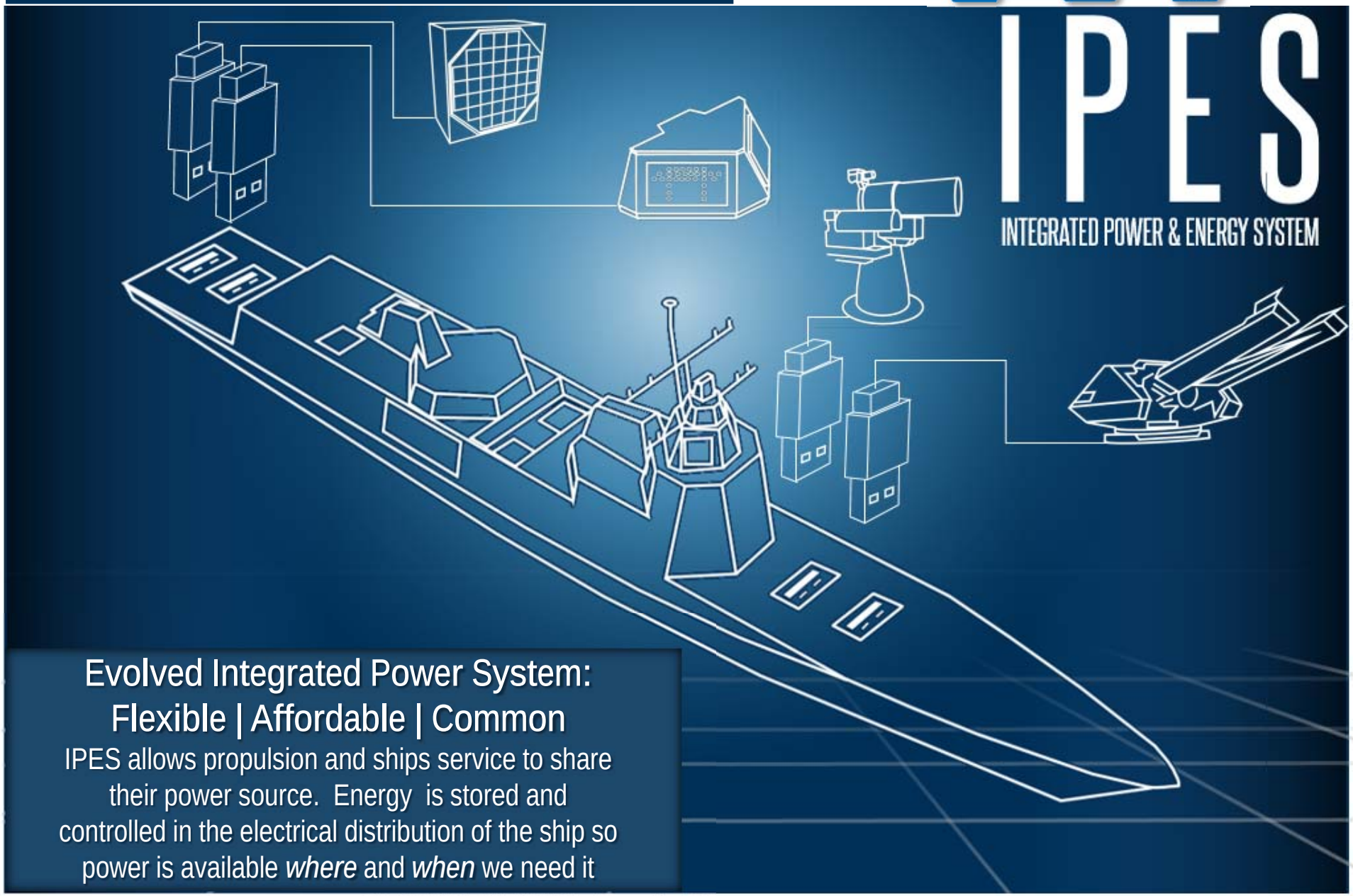
Energy Magazine

Common Architecture

- Shifts the Interface
- Flexible for Growth
- Adds Functionality
- Affordable
- Saves Space & Weight

Shifts the interface towards the loads for affordability and commonality

INTEGRATED POWER AND ENERGY SYSTEM (IPES)

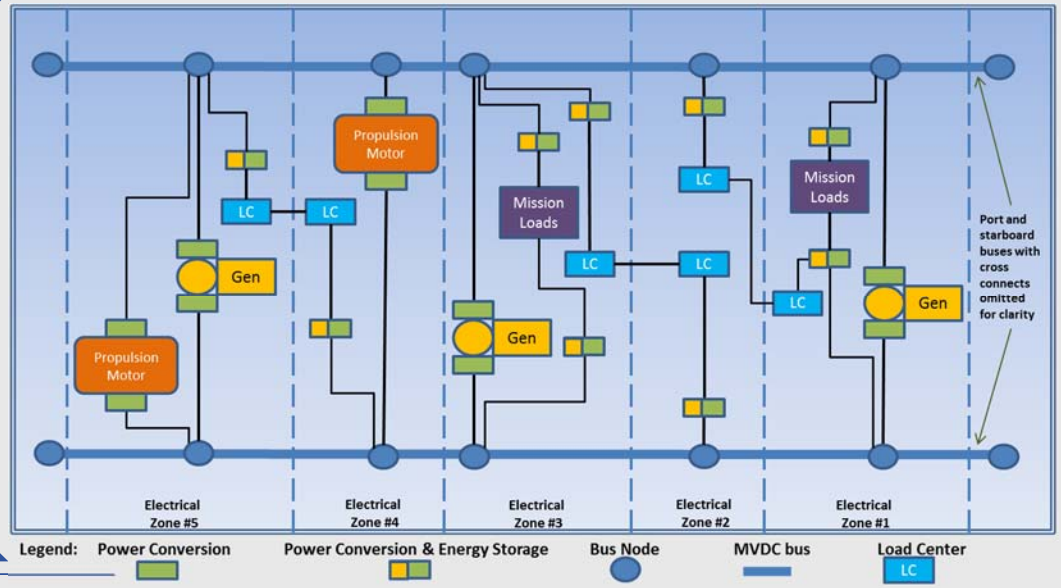


Evolved Integrated Power System: Flexible | Affordable | Common

IPES allows propulsion and ships service to share their power source. Energy is stored and controlled in the electrical distribution of the ship so power is available *where* and *when* we need it

FUTURE SURFACE COMBATANT

INTEGRATED POWER & ENERGY SYSTEMS (IPES)



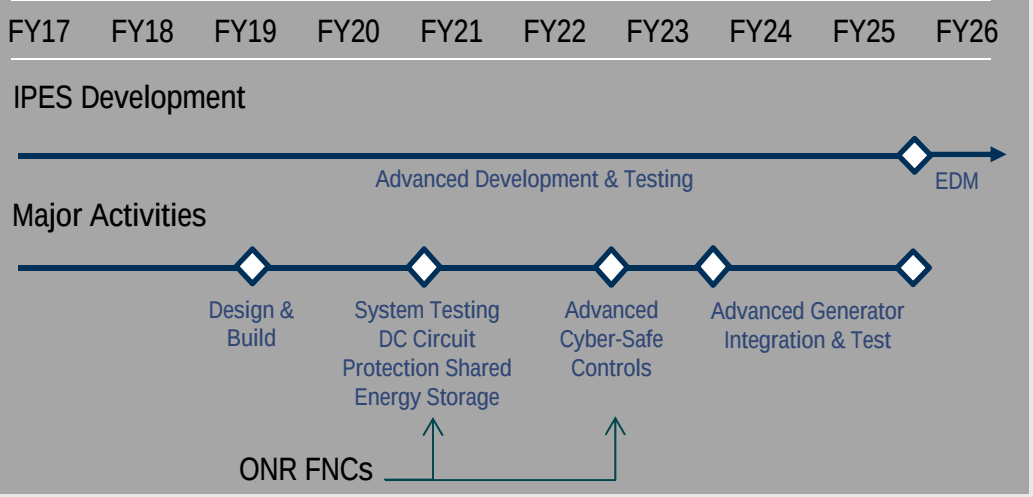
Is:

- Evolutionary from DDG1000 IPS
- Shared energy storage
- Advanced controls with combat systems interface
- Affordable, Scalable, and Flexible
- Zonal 12KVDC integrated power and energy
- MVDC IPES ADM White Paper of 08 April 2016 contains a full description

WARFIGHTING BENEFITS:

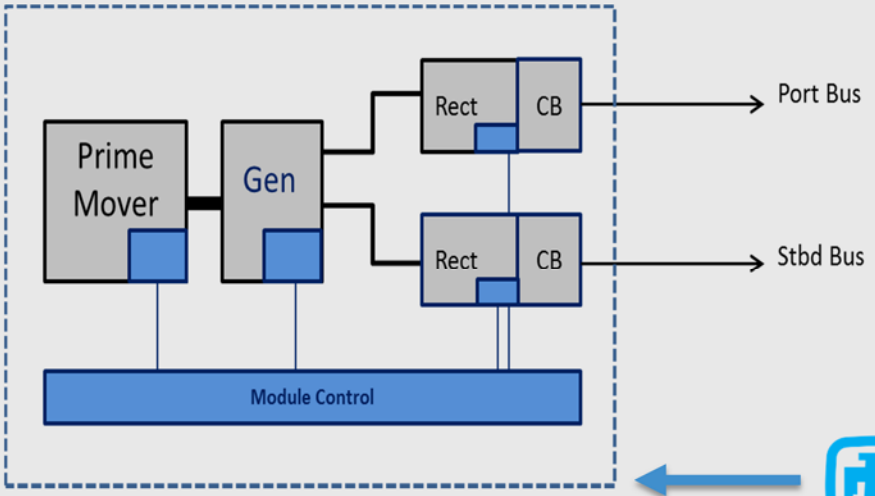
- Decouples mission system pulse loads from power generation
- Seamlessly transitions power and energy to high power pulsed weapons and sensors as required while maintaining system stability
- Matures and tests control system Active Power Management and Cybersecurity
- De-risks integration of modular energy storage at the main distribution and/or zonal levels

SCHEDULE:



ADVANCED POWER GENERATION MODULE (APGM)

25MW 12KVDC GTG



Key Attributes:

- High Power Density
  - Fits in a warship less than10,000 tons
- DC permits use of variable speed to optimize efficiency
- Dual windings for independent buses
- Independent rectifiers convert AC → DC
- Module level controls
- Isolation from pulsed and/or stochastic load profiles
- Accommodation of high energy weapons (DC loads)

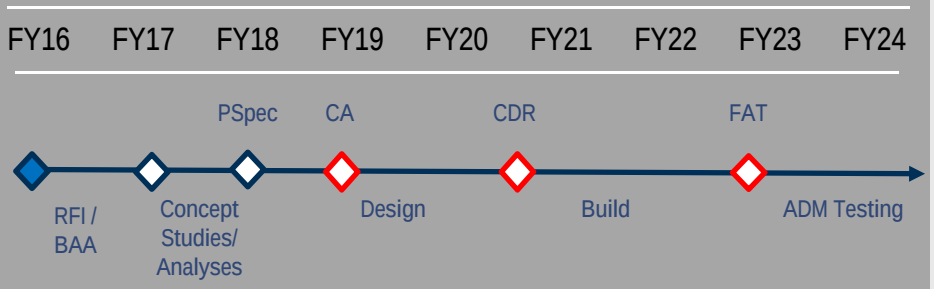
Sandia National Laboratories → Building Scale Generator and Testing to Inform interface

WARFIGHTING BENEFITS:

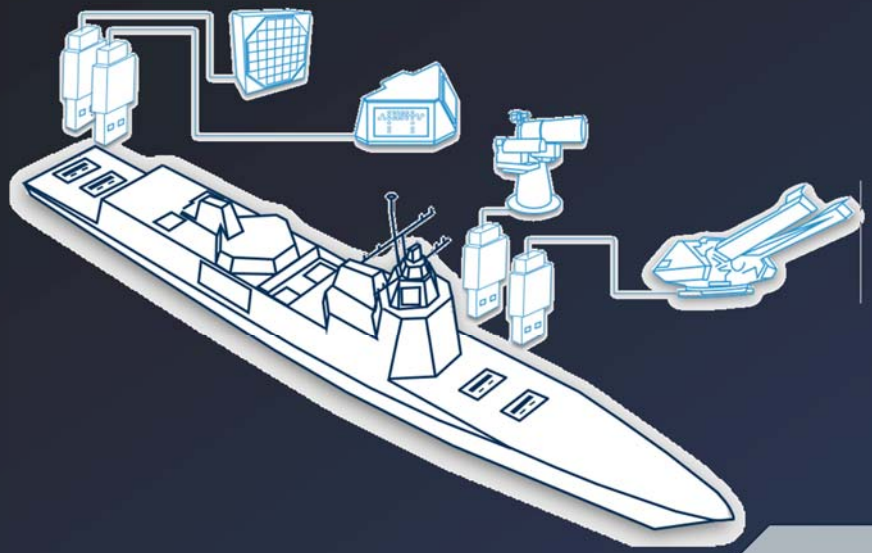
- Provides power dense and fuel efficient electrical generation capability
- Supports ships with future high power pulsed weapons and sensor systems in an IPES configuration
- Will be incorporated into IPES ADM upon delivery

PLANNING:

- ✓ FY16: Industry RFI and Industry Day
- FY17/18: Industry/Government Studies
  - Sandia: Building scale APGM emulator, test in 300 VDC microgrid lab to inform system performance requirements.
  - Study contracts to 6 industry teams



IPES: Advanced Cyber Safe Control System

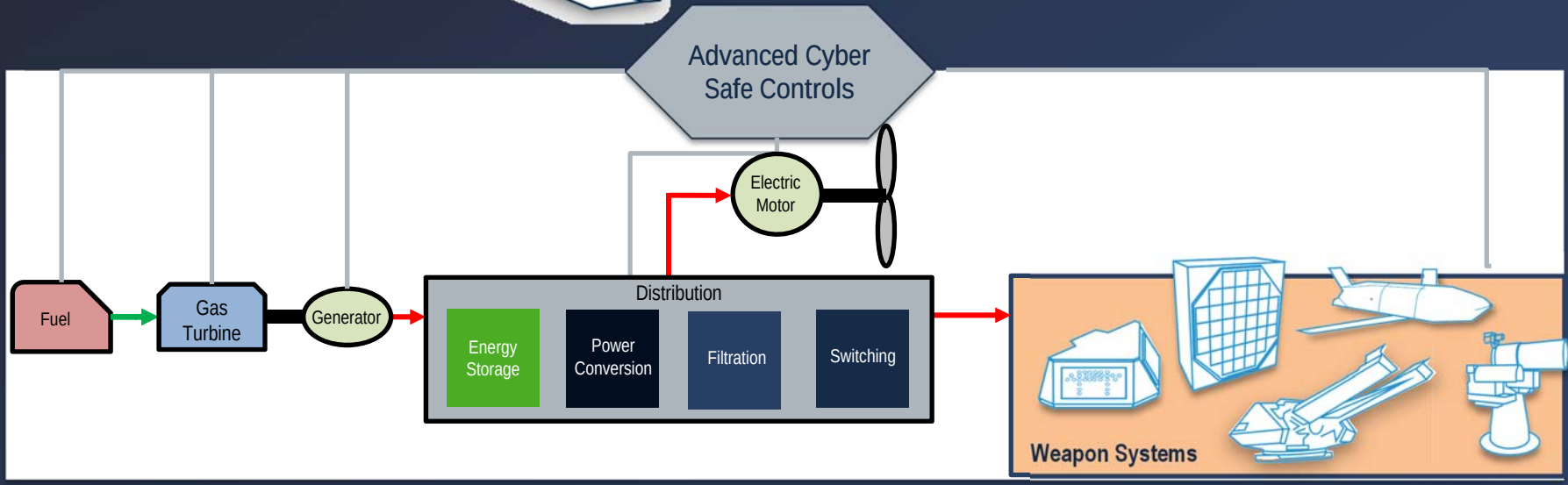


Integrated Power & Energy System

Flexible | Common | Modular | Scalable

Shared Power and Energy is controlled and distributed so power is available *where* and *when* needed.

IPES = IPS + Shared Energy + Advanced Controls



The Right Power in the Right Place at the Right Time

Electric Ships Office
PMS 320
Directing the Future of Ships Power

OVERVIEW

In 2007, ASN(RDA) established PMS 320, the Electric Ships Office (ESO) within PEO SHIPS to facilitate the high degree of technical integration with ship platforms and power systems, scope future technology development, and support critical concept decisions.

OUR MISSION

The mission of PMS 320 is to develop and provide affordable, capable Naval power and energy system integration solutions to meet evolving customer demands by:

- Defining common open architectures and interface standards,
- Developing common solutions,
- and Focusing Navy and informing Industry investments

OUR VISION

PMS 320 will work across the Navy's Research & Development Enterprise in partnership with industry to develop and introduce innovative technologies to enable the Navy's distributed lethality principles through efficient power & energy management.

PMS 320...

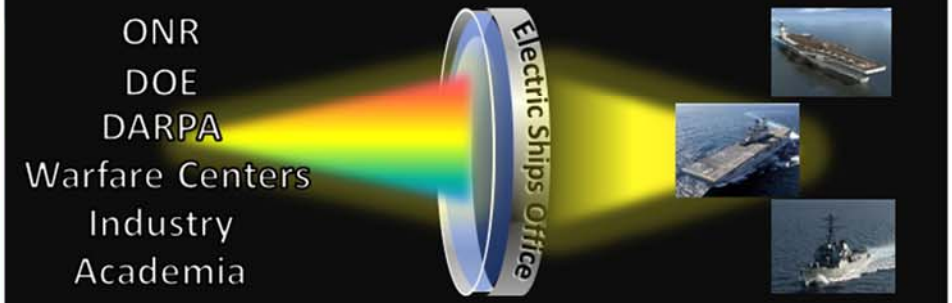
- Manages the Combat Power and Energy Systems OIPT
- Works with the S&T community to apply new technologies to solve fleet problems
- Works in conjunction with ONR, DARPA, Academia, Industry Professionals, and Warfare Centers
- Aligns developments with warfighter needs
- Supports SECNAV and CNO initiatives to reduce energy use

WHAT WE PRODUCE

- Smaller, simpler, and more affordable ship power systems
- Power for pulsed high energy weapons and sensor systems
- Future Naval Power Systems and transition appropriate Science & Technology to the fleet
- Naval Power and Energy Systems Technology Development Roadmap (TDR)

NPES TDR:
http://www.navsea.navy.mil/teamships/PEOS_ElectricShips/default.aspx

Providing Affordable, Integrated Power and Energy Solutions



- Provide fuel efficient and affordable power to meet power requirements for advanced sensors and future weapons
- Reduction in weight and lower life cycle costs
- DDG 51 Flight III AG9160RF rating is 4MW with 3.3% fuel efficiency improvement from DDG 1000 RR4500 3.85MW ATG

- Provides power conversion from DDG 51 Flight III 4160 VAC distribution system to 1000VDC at 1.42 MW/unit output power
- The two PCM cabinets can be paralleled via auctioneering diodes (in AMDR) and will share the AMDR load

- 12 kVDC Architecture
- IPS + Shared Energy Storage + Advanced Controls
- Enables multiple pulsed, high power mission systems

- De-risks SSL for all ships; creates modular building block for flexible commonality
- Facilitates integration of future weapon/sensor systems

- Fit into a DDG-51 size ship
- 25 MW
- Variable speed DC output

- Reduce DDG 51 FLT IIA Class in-service fuel consumption and increase on station time
- Provides propulsion at low ship speeds without the need for LM 2500 main engines
- Output Power: 2550 HP (1.9MW) - port shaft only